Space Technology Research Grants

Multi-Scale Modeling of Crack Nucleation and Growth in Additively Manufactured Alloys

Completed Technology Project (2013 - 2017)

Project Introduction

Additive manufacturing (AM) promises growth in design space, increased speed of production, and decreased cost to aircraft and space technology engineering. For this new process to be fully integrated into NASA's fabrication pipeline, a comprehensive understanding of component reliability (and therefore, fatigue life and failure) must be obtained. Thus, the goals of this project are to provide definitive results outlining the strength and reliability of AM materials for NASA, as well as to provide a digital platform and methodology for further tests. The approach to this project involves two parallel thrusts: -I will explore the effect of defects characteristic of AM (voids, inclusions, and impurities) on fatigue life in order to better comprehend the governing modes of AM fracture initiation in NASA mission environments. Specifically, I will study short crack nucleation from these defects in aluminum, a popular material in both AM and aerospace applications. -I will undertake this exploration via atomistic-scale simulation, using physics-based models which will be applicable to a wide range of defect sizes and load cases. One large challenge I expect to encounter is the inherent computational intensity of atomistic simulation. Though much progress has been made with respect to efficiently computing these experiments in a tractable clock time, the desire for larger atomistic windows will always persist, and the veracity of my results must always be interpreted with this in mind. The outcomes of this project are designed to help NASA effectively utilize AM technology now and in the future. Instead of long wait times on costly experiments, this software will allow for the characterization of new materials and new AM processes computationally. This will shorten the pipeline between material development and mission implementation, as well as be useful as a design tool for exploring new materials and AM methods. Additionally, these results will be applicable to all.

Anticipated Benefits

The outcomes of this project are designed to help NASA effectively utilize AM technology now and in the future. Instead of long wait times on costly experiments, this software will allow for the characterization of new materials and new AM processes computationally. This will shorten the pipeline between material development and mission implementation, as well as be useful as a design tool for exploring new materials and AM methods. Additionally, these results will be applicable to all.

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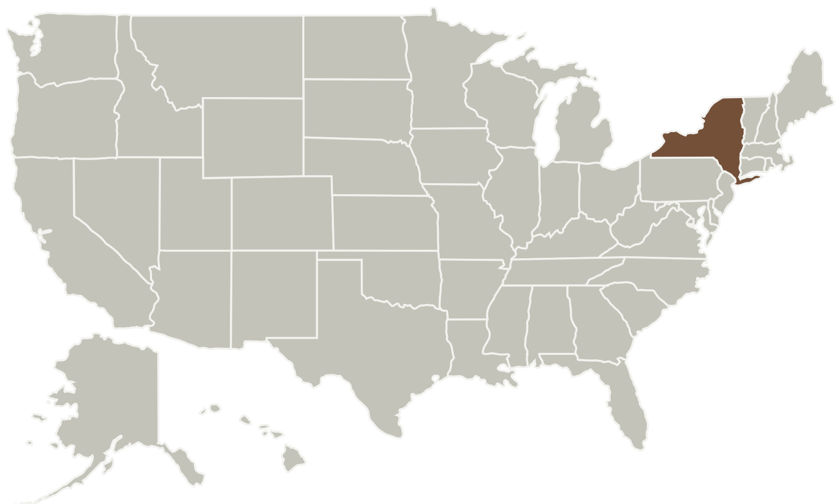
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Cornell University	Lead Organization	Academia	Ithaca, New York

Primary U.S. Work Locations
New York

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Cornell University

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

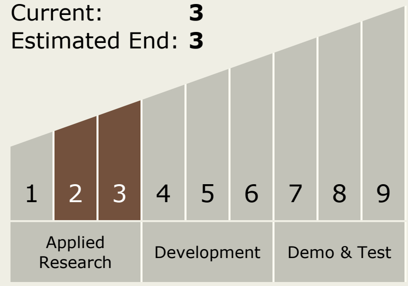
Nicole Benedek

Co-Investigator:

Ethan T Ritz

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  - └ TX09.4 Vehicle Systems
    - └ TX09.4.5 Modeling and Simulation for EDL

Target Destination

Foundational Knowledge